

This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

**As rescanning documents *will not* correct images,
please do not report the images to the
Image Problem Mailbox.**

EUROPEAN PATENT APPLICATION

Application number: 87301705.7

Int. Cl.4: F01N 3/02 , B01D 46/24

Date of filing: 26.02.87

The title of the invention has been amended
(Guidelines for Examination in the EPO, A-III,
7.3).

Priority: 28.02.86 GB 8605058

Date of publication of application:
04.11.87 Bulletin 87/45

Designated Contracting States:
AT BE CH DE ES FR GB GR IT LI LU NL SE

Applicant: **POROUS ELEMENT HEATING
LIMITED**
Havenside
Boston Lincolnshire PE21 0AH(GB)

Inventor: Hudson, John Christopher
17 Sibsey Road
Boston Lincolnshire(GB)
Inventor: Thantrey, Shok
81 Fishtoft Road
Boston Lincolnshire(GB)
Inventor: Jackson, Ian Martin
63 Clarke Court
Boston Lincolnshire(GB)

Representative: Harrison, Philippa Dinah et al
A. A. THORNTON & CO Northumberland
House 303-306 High Holborn
London WC1V 7LE(GB)

Process and apparatus for the removal of particulate material from a gas.

Filtering apparatus for removing combustible particles from a gas, e.g. carbon and hydrocarbon particles from the exhaust gases of a diesel engine, comprises at least one filter element 23 which is made of fibrous material and is electrically conductive. To remove trapped particles from the filter element 23 and thereby regenerate the filter element, electrical power is supplied to the filter element to heat it to the point at which the carbon and hydrocarbon particles combust.

One or a plurality of such filter elements 23 may be provided in a housing 20 in the exhaust gas system of a diesel engine with the filter elements exposed in parallel to exhaust gases. For regeneration, all filter elements may be simultaneously regenerated while exhaust gases are either exhausted direct to the air or through a similar filtering apparatus. Alternatively the filter elements may be regenerated sequentially so that at least some of the filter elements are always effective as filters. During regeneration exhaust gases are substantially excluded from a filter element undergoing regeneration and

this may be effected by preventing flow of the exhaust gases to the filter element while it is being regenerated or by increasing the pressure downstream of the filter element to prevent exhaust gases flowing through the filter element.

Each filter element 23 is preferably annular and arranged so that exhaust gases flow through the wall in a radially inward direction.

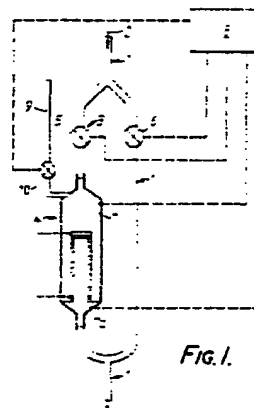


Fig. 1.

EP 0 244 061 A1

Improvements in and relating to the removal of particulate material from a gas

The present invention relates to apparatus for the removal of particulate material from a gas, particularly combustible particulate material, for example carbon and hydrocarbon particles from the exhaust gas of a diesel engine.

There is increasing interest in the efficient and effective limitation of emission of particulate material, generally carbon and hydrocarbon particles, from the exhaust gases of diesel engines and devices have been proposed for this purpose which generally comprise a filter mounted in the diesel engine exhaust system and in which the carbon particles are trapped. However, presently proposed filters become blocked very rapidly so that it is necessary to intermittently remove the carbon particles from the filter during operation of the diesel engine. It has been proposed to effect this by intermittently heating up gases entering the filter to a temperature at which the carbon particles will combust, generally by providing a heat source upstream of the filter which is activated intermittently.

According to the present invention, there is provided apparatus for removing combustible particles from a first gas comprising a housing through which the first gas is caused to flow and having an inlet for gas and an outlet and, mounted within said housing, a filter element through which in use the first gas will flow and which is made of electrically conductive material, and means for connecting said element to an electrical power supply for heating said element to a temperature at which the particles trapped thereby will combust for regeneration of said element.

It will be appreciated that the electrical resistance of the material of the filter element is selected relative to the power supply to enable the filter element to be heated to the required temperature for combustion of the combustible particles.

In use, when it is required to remove the trapped particles from the filter element, power is supplied to the filter element to heat it to the required temperature. With such an arrangement, because the combustible particles are heated directly by the filter element, rather than as previously proposed indirectly by heating gas flowing through the filter, less power is required to cause combustion of the particles.

Preferably means are provided for substantially reducing the flow of the first gas through the filter element when it is connected to the power supply to minimise cooling of the element by the first gases and therefore minimize losses of thermal

energy from the element. A small flow of gas, which may be the first gas or an auxiliary combustion supporting gas, is required but only to provide sufficient oxygen to support combustion.

The filter element may be annular and closed at one end, the filter element being arranged in the housing so that the first gas flows substantially radially inwardly to the interior of the element and out of the open end. With such a filter element, combustion supporting gas may be supplied from the open end to the interior of the element at a sufficient pressure that it prevents or substantially prevents flow of exhaust gases through the filter element.

The apparatus may comprise a plurality of filter elements arranged in parallel for simultaneous exposure to the first gas to be filtered thereby and the means for connecting the elements to an electrical power supply may be arranged so that all the elements are connected simultaneously for simultaneous regeneration or so that the elements are connected sequentially for sequential regeneration.

The present invention will be more fully understood from the following description of embodiments thereof, given by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic representation of part of a diesel engine exhaust system including an embodiment of apparatus according to the present invention;

Figure 2 is a section through the embodiment according to the present invention as shown in Figure 1;

Figure 3 shows diagrammatically circuitry associated with the apparatus of Figures 1 and 2;

Figure 4 is a section through another embodiment of apparatus according to the present invention;

Figure 5 shows diagrammatically circuitry associated with the apparatus of Figure 4;

Figure 6 is a diagrammatic representation of part of a diesel engine exhaust system incorporating the embodiment of Figure 4; and

Figure 7 shows diagrammatically circuitry associated with a modification of the apparatus of Figure 4.

In Figure 1 there is shown an exhaust pipe 1 of a diesel engine through which exhaust gases flow in the direction of arrow 2. Conventionally such exhaust gases would flow from the pipe 1 to the atmosphere, optionally through a muffler (not shown). As shown in Figure 1, the exhaust pipe 1 is provided with a branch pipe 3 including filtering apparatus 4 for removing particles, which are generally carbon and hydrocarbon particles, in the

exhaust gases. Branch pipe 3 is provided, upstream of apparatus 4, with a valve 5 and a valve 6 is also provided in exhaust pipe 1 downstream of its connection with branch pipe 3. In operation, these valves are alternatively opened and closed to permit the exhaust gases from the engine to flow either through exhaust pipe 1 or through exhaust pipe 3 and apparatus 4 as will be described hereafter.

It will be appreciated that valve 5 may alternatively be positioned in branch pipe 3 downstream of apparatus 4 rather than as shown upstream. Additionally valves 5 and 6 may be combined in the form of a multiposition valve positioned at either the upstream or the downstream junction between pipes 1 and 3.

Apparatus 4, shown in more detail in Figure 2, includes one or a plurality of filter elements through which the exhaust gases flow and which trap particles therein. During operation of the diesel engine, initially valve 6 is closed and valve 5 is opened so that the exhaust gases flow through branch pipe 3 and apparatus 4. Flow through apparatus 4 continues until the or each filter element becomes partially clogged with particles. This may be detected, as shown, by the consequential increase in the pressure in the inlet of apparatus 4 which may, for example, be sensed by a pressure detector 7. When the pressure detected by detector 7 reaches a predetermined level, valve 5 is closed and valve 6 is opened to permit the exhaust gases to flow through the main exhaust pipe 1 to the atmosphere. Closing and opening of valves 5 and 6 is effected automatically by control means 8 to which the output of the pressure detector 7 is supplied.

The or each filter element in apparatus 4 is made of electrically conductive material which has an electrical resistance such that it itself serves as a heater for heating up the carbon or hydrocarbon particles trapped therein to a temperature at which they will combust. The or each filter element is connected by switch means, to be described hereafter, to a power supply, which may for example be the engine battery or alternator, the switch means being under the control of control means 8 so that, on closing of valve 5, the switch means is operated to supply power to the or each filter element to heat it to the combustion point of the carbon or hydrocarbon particles for regeneration of the filter element. For combustion, a small supply of oxygen is required sufficient to support combustion and this may be provided by only partially closing valve 5 when it is in its "closed" position so as to permit some exhaust gases to flow sufficient to support combustion. Alternatively an auxiliary combustion supporting gas, e.g. air, may be supplied to the or each filter element. As shown in Figure 1, air is supplied to the inlet of apparatus 4 via a pipe 9

provided with a valve 10 which is opened as valve 5 is closed (and closed with opening of valve 5) under the control of control means 8. The supply of air for pipe 9 may for example be taken from the vehicle compressor or any other suitable source of air or oxygen.

As soon as all or substantially all of the carbon and hydrocarbon particles in the or each filter have been burnt away, which may be indicated by a change in the pressure downstream of the element or elements and detected by a second pressure detector 7a, valve 10 is closed, valve 5 is reopened and valve 6 is closed by control means 8 so that the exhaust gases are again diverted through branch pipe 3 and filtering apparatus 4. In a modification, the auxiliary combustion supporting gas may be supplied to the outlet of apparatus 4 and caused to flow through the or each filter element in the opposite direction to the direction of flow of the exhaust gases.

In a modification of the above described system whereby all exhaust gases from the diesel engine are filtered, filtering apparatus corresponding to apparatus 4 may also be provided in the main exhaust pipe 1, the two apparatus being regenerated alternately.

Furthermore, as an alternative to the use and provision of a pressure detector 7 to initiate and termination regeneration of the filters and operation of valves 5, 6 and 10, control means 8 may include a timing system which is used to control the valves and initiate and terminate regeneration. With such a system, the or each filter element is regenerated for a predetermined period of time in each set period of time in which the diesel engine is running, the periods being determined in dependence on the particular circumstances of use to ensure that the or each filter element is adequately regenerated and regenerated before it becomes too clogged with particles.

The filtering apparatus 4 shown in Figure 1 is shown in greater detail in Figure 2. It comprises a housing 20 having an inlet 21 and an outlet 22 for connection in the exhaust branch pipe 3. Within the housing 2 a plurality of filter elements 23, as shown three elements, are provided which elements are arranged in effect in parallel for simultaneous flow of exhaust gases therethrough. The filter elements are cylindrical and have annular walls, the interior of each element being open at one end 24 and closed at the other end 25.

A plate 26 adjacent the outlet 22 of the housing spans the housing and divides it into an inlet manifold or chamber 27 between plate 26 and inlet 21 and an outlet manifold or chamber 28 between plate 26 and outlet 22. The filter elements 23 extend within manifold 27 and the plate 26 is provided with apertures 29 which are aligned with

the open ends 24 of the filter elements 23 and through which the outlet manifold 28 communicates with the interiors of the filter elements, whose closed ends 25 are presented to inlet manifold 27.

In use, exhaust gases entering inlet 21 flow into manifold 27 and around the outsides of the filter elements 23, then substantially radially through the walls of the filter elements 23 into the interiors, then through apertures 29 and into the outlet manifold 28.

For connection of an electric power supply to the filter elements 23, each end 24,25 is provided with a contact plate 30,31. Contact plate 30 is annular and contact plate 31 also forms a closure for closing the end 25 of the element. The contact plates 30,31 are connected to insulated wires 33 which are connected to terminals 34 mounted externally on the housing 20.

The filter elements 23 and their contact plates 30,31 are insulated from the housing by insulators 35,36. Insulator 35, which is annular, is shaped to positively engage with contact plate 30 and to seat in the respective opening 29 to plate 26. Insulator 36 which is in the form of a plate is also shaped to make positive engagement with contact plate 31. Each of the assemblies of filter element 23, contact plates 30,31 and insulators 35, 36 is positively biased into engagement with each other and with the plate 26 by a helical spring 37 acting between insulator plate 36 and a bracket 38 mounted on and within the housing 20.

The elements 23 are, as shown in Figure 3, connected in parallel across a suitable power supply 40, for example the engine battery or alternator, and the circuit includes a switch 41 which is opened and closed by the control means 8 as described above. Alternatively the elements 23 may be connected in series with switch 41 and power supply 40.

While as described above, three filter elements 23 are provided it will be appreciated that the apparatus 4 may comprise one, two or more than three filter elements 23, the number of filter elements provided depending on the exhaust emissions and on the size and efficiency of the or each element 23.

The filtering apparatus 4 shown in Figures 1 to 3 may be modified, as shown in Figures 4, 5 and 6 to enable all exhaust gases to be passed through it. With this modification, which will be described hereafter, the modified filtering apparatus 4a can, as shown in Figure 6, be connected directly in the exhaust pipe 1 of the diesel engine, bypass 3 and valves 5,6 being omitted. As will be described hereafter, the apparatus 4a includes a plurality of filter elements and a combustion supporting gas supply is required for each element. The apparatus shown in Figure 6 thus comprises supply pipe 9,

as in the apparatus of Figure 1, which is provided with a valve 10 but in this case valve 10 is a multi-position valve having a closed position and positions supplying gas to each of the individual supply pipes 9a for each filter element. As in the previous embodiment, valve 10 is controlled by control means 8 which, in this embodiment, includes a timer for operating valve 10 and initiating and terminating regeneration of the filter elements, as will be described hereafter.

The apparatus as shown in detail in Figure 4 is similar to that of Figure 2 and like reference numerals are used for like parts, which will not be further described. The primary differences between the apparatus shown in Figure 4 and that shown in Figure 2 are the electrical connection of the filter elements 23, which is most clearly shown in Figure 5, and the configuration of components at the open outlet end 24 in relation to the supply of combustion supporting gas. In relation to the latter, the combustion supporting gas is supplied to each filter element 23 in a direction counter-current to the direction of flow of exhaust gases therethrough and the arrangement is such that supply of the combustion supporting gas to a filter element will effectively prevent flow of exhaust gases through the walls thereof. Thus by this arrangement the supply of combustion supporting gas to a filter element effectively serves the function of a valve or other means substantially preventing supply of exhaust gases thereto while regeneration is taking place.

More specifically, as shown in Figure 4, the inner periphery of the opening in contact plate 30 and insulator 35 at the open end 24 of each filter element 23 is shaped to provide in this region a restriction in the flow cross section for exhaust gases. As shown, in this region the flow cross section progressively decreases and then progressively increases, insulator 35 having been axially extended relative to that of Figure 2. Additionally the outlet end portion 50 of each pipe 9a providing combustion supporting gas to a respective filter element 23 has a generally bullet-shaped configuration, the axis of the bullet being aligned with the axis of the filter element and the outlet 51 for gas is directed along the axis of the element counter-current to the direction of flow of exhaust gases.

The filter elements 23 are designed so that two out of the three elements are sufficient to filter exhaust gases generated by the diesel engine at any one time and the period for regeneration of any one filter element is one third, or less than one third, of the time between each regeneration of a filter.

As regards the connection of the filter elements 23 to the power supply, as shown in Figure 5 they are individually connectable through a multi-position switch 41, under the control of control means 8, to the power supply 40, operation of switch 41 being synchronised with operation of valve 10 as will be described hereafter.

With the above described apparatus in use, at the point when a filter element 23 requires regeneration, valve 10 is moved to the position supplying combustion supporting gas to the related pipe 9a and at the same time switch 41 is moved to the position connecting the filter element to the power supply. Supply of the combustion supporting gas to the interior of the element has, as described above, the effect of substantially preventing flow of further exhaust gases through the element which then heats up to the point at which particles trapped thereby combust. Since combustion is exothermic, the supply of power to the filter element may be cut off before combustion is complete, at the point at which combustion provides sufficient heat to be self supporting but the supply of combustion supporting gas is continued up to the end of the regeneration period. At that point valve 10 is moved to its closed position and the element resumes operation as a filtering element. The control means 8 operates so that the filter elements 23 are regenerated sequentially so that at any one time at least two of the elements are operating as filter elements while the third may be subject to regeneration. As previously mentioned, for convenience, the regeneration of the elements is controlled by a timer. It could alternatively be controlled by relative pressure as in the embodiment of Figures 1 to 3 but this would increase the cost of the apparatus.

At the end of a period of use of the engine, when the engine is switched off the timer associated with control means 8 is also switched off and then re-started when the engine is re-started to ensure that sequential regeneration of the filter elements is maintained throughout the period of installation of filter apparatus in the exhaust system of the engine.

It will be appreciated that, with larger filter elements or reduced exhaust, only two filter elements may be provided, the elements being regenerated alternately. With smaller filter elements or to deal with larger quantities of exhaust, a greater number of filter elements may be provided. Where the regeneration time of any one filter element is in excess of the period of time between successive regenerations of any one filter element divided by the number of filter elements, the elements may then be electrically connected in groups with groups of elements being regenerated successively. The electrical circuitry for such an arrangement

is shown diagrammatically in Figure 7 in which each group of filter elements comprises two filter elements and the filtering apparatus comprises three groups in total.

In a modification of the above described apparatus, an exhaust gas by-pass for apparatus 4 may be provided in effect as in the embodiment of Figure 1 with individual or a multiposition valve for controlling flow of exhaust gases either through the apparatus 4 or through the by-pass. However in this modification, the valves or multiposition valve are operated by the control means 8 under the control of a pressure detector sensing pressure within apparatus 4 either upstream or downstream of the filter elements with a view to bypassing the apparatus 4 only in the event of a malfunction of the apparatus 4. A malfunction resulting from insufficient regeneration of the filter elements would be indicated by an increase in pressure upstream of the elements or a decrease in pressure downstream of the elements above or below respectively preset pressures.

The above described filter elements 23 are made of randomly arranged fibres of silicon carbide which provided tortuous paths for gases there-through. Preferably the silicon carbide fibres are hollow. Such a filter element may be made from a carbon fibre precursor which may for example be made in accordance with U.K. Patent No.1600253 from a fibrous element made in accordance with U.K. Patent No.1503644. The fibrous material of the initial fibrous element may for example have a bulk density of 70 to 100 kgm³. Such a carbon fibre element is heated in a furnace to a temperature of the order of 680°C. The furnace is evacuated and an inert gas, for example argon, is introduced together with a reactant gas comprising 60% silane and 40% ethylene with a dopant comprising 1% phosphine in argon. Silicon carbide is thus deposited onto the carbon fibre element to provide a coating of silicon carbide, for example of the order of 8 microns thick, over the carbon fibres. The coated element is then heated to a temperature of about 800°C to oxidise and thereby remove the carbon fibres to leave hollow silicon carbide fibres. The silicon carbon element is then subject to further heat treatment, for example by heating the element in an inert atmosphere, for example of argon, at a temperature of about 1,350°C to provide the element with the required resistivity.

The resulting element is then machined to provide a filter element of the required dimensions and the ends of the filter element are treated, for example by flame spraying e.g. with stainless steel or Nichrome powder or wire, in order to reduce the contact resistance at the ends of the filter element between the fibres of the filter element and the contact plates 30,31.

The resulting filter element, if annular, may have an outside diameter of 60 mm, an inside diameter of 52 mm and may be 120 mm long. Advantageously the resistance is of the order of 0.2 to 2.0 ohms, the resistance selected depending on the voltage of the power supply to be connected to it.

A filter element as described above, is found to present a relatively small resistance to flow of gases, for example to create a backpressure of the order of or less than 10 ins water and has a high trapping efficiency of the order of 60 - 80%. As with known systems, it is considered that, when the backpressure across a filter element partially clogged with particles reaches about 30 ins water, the filter element requires regeneration.

Because the filter is itself heated to initiate combustion of the carbon or hydrocarbon particles, the power required and the duration of the supply of power for regeneration can be significantly reduced as compared with known filtering apparatus.

The filter element may include a catalyst for reducing the combustion temperature, normally 600°C to 625°C, at which the carbon particles combust. The catalyst may be applied to the surface of the fibres or incorporated in the fibres of the element. The catalyst may, for example, comprise a coating on the fibres of alumina or silica or a mixture of alumina and silica which may be applied by a washcoating or similar technique.

Claims

1. Apparatus for removing combustible particles from a first gas comprising a housing (20) through which the first gas is caused to flow and having an inlet (21) for gas and an outlet (22) and, mounted within said housing, a filter element (23) through which in use the first gas will flow characterised in that the filter element (23) is made of electrically conductive material, and means (33, 41) are provided for connecting said element (23) to an electrical power supply (40) for heating said element to a temperature at which the particles trapped thereby will combust for regeneration of said element.

2. Apparatus as claimed in claim 1, characterised by means (5; 50) for at least substantially reducing the flow of the first gas through said element (23) when connected to the power supply.

3. Apparatus as claimed in claim 2, characterised in that said means for substantially reducing flow of the first gas through said element comprises a valve (5) connected to said inlet (22) of said housing (20) for controlling flow of gas to said inlet.

4. Apparatus as claimed in claim 3, characterised in that said valve (5) is arranged so that in the closed condition thereof a reduced flow of gas enters said housing for providing sufficient oxygen to support combustion.

5. Apparatus as claimed in any one of the preceding claims, characterised by means (9, 10) for supplying an auxiliary combustion supporting gas to said housing (20) when said element is connected to the electrical power supply.

6. Apparatus as claimed in claim 5, characterised by control means (8) for controlling said means for substantially reducing the flow of first gas through said element and for supplying said auxiliary gas to said housing and for connecting said element to an electrical power supply.

7. Apparatus as claimed in either claim 5 or claim 6, characterised in that said auxiliary gas supply means (9, 10, 50) is arranged so that said supply of said auxiliary gas thereby will substantially prevent the first gas flowing through said element to thereby provide said means for at least substantially reducing the flow of first gas through said element.

8. Apparatus as claimed in any one of the preceding claims, characterised in that said element (23) is generally cylindrical and comprises an annular wall and is arranged in said housing so that the first gas will flow substantially radially through said wall thereof.

9. Apparatus as claimed in claim 8, characterised in that said element is arranged in said housing so that the first gas will flow substantially radially through said wall thereof from the exterior to the interior thereof.

10. Apparatus as claimed in claim 9, characterised by means (31) closing one end (25) of said element (23), the other end (24) being open to permit the first gas to flow from the interior thereof to the outlet (22) of said housing (20).

11. Apparatus as claimed in claim 10, characterised in that said auxiliary gas supply means (9, 10) comprises an outlet portion (50) which is arranged in the region of said open end (24) of said element (23) for directing auxiliary gas into the interior of said element.

12. Apparatus as claimed in claim 11, characterised in that in the region of said open end (24) of said element (23), the flow path for gas therefrom is shaped relative to said outlet portion (50) of said auxiliary gas supply means so that supply of auxiliary gas to the interior of said element substantially prevents flow of said first gas through said element.

13. Apparatus as claimed in either of claim 11 or claim 12, characterised in that in the region of said open end (24) of said element (23), said flow path for gas therefrom is reduced relative to the

flow path in said interior of said element, said reduction being progressive in the direction of flow of said first gas from said element and said flow path progressively widening downstream of said reduction.

5

14. Apparatus as claimed in claim 13, characterised in that said outlet portion (50) of said auxiliary gas supply means is arranged substantially centrally in said region of said open end (24) of said element (23) to direct the auxiliary gas axially into the interior of said element and has a generally bullet-shaped exterior profile.

10

15. Apparatus as claimed in any one of the preceding claims, characterised in that a plurality of said elements (23) are mounted in said housing for simultaneous flow of gas therethrough.

15

16. Apparatus as claimed in any one of claims 10 to 14, characterised in that said housing is provided with a wall (26) separating the interior thereof into an inlet chamber (27) and an outlet chamber (28), and a plurality of said filter elements are mounted on said wall (26) with their open ends (24) aligned with openings in said wall and extending within said inlet chamber.

20

17. Apparatus as claimed in either claim 15 or claim 16, characterised in that said means for connecting said elements (23) to an electrical power supply comprise switch means (41) for connecting said elements sequentially to an electrical power supply.

25

30

18. Apparatus as claimed in either claim 15 or claim 16, characterised in that said means for connecting said elements (23) to an electrical power supply comprise means for connecting said elements in parallel in groups thereof and switch means (41) for connecting each group of elements sequentially to an electrical power supply.

35

19. Apparatus as claimed in either claim 15 or claim 16, characterised in that said means for connecting said elements (23) to an electrical power supply comprise means connecting said elements in parallel and switch means (41) for connecting said elements simultaneously to a power supply.

40

20. Apparatus as claimed in any one of the preceding claims, characterised in that the element (23) is made of randomly arranged fibres of electrically conductive material.

45

21. Apparatus as claimed in claim 20, characterised in that said fibres comprise silicon carbide.

22. Apparatus as claimed in claim 21, characterised in that said fibres are hollow.

50

23. Apparatus as claimed in any one of claims 20 to 22, characterised in that the fibres are coated with alumina, silica or a mixture of alumina or silica.

24. Apparatus as claimed in any one of claims 20 to 23, characterised in that the or each element includes a catalyst for reducing the combustion temperature of the combustible particles.

55

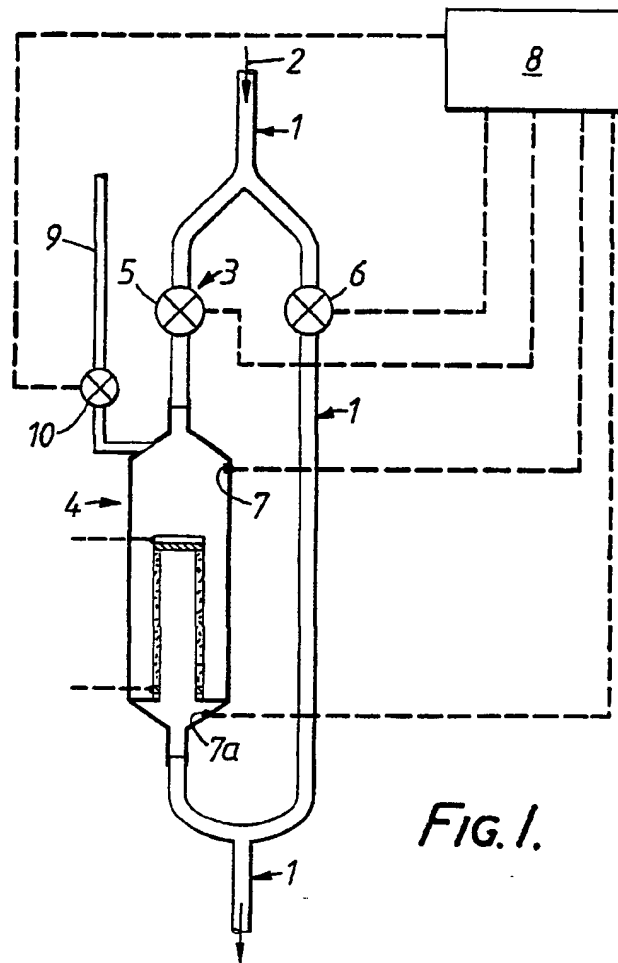


FIG. 1.

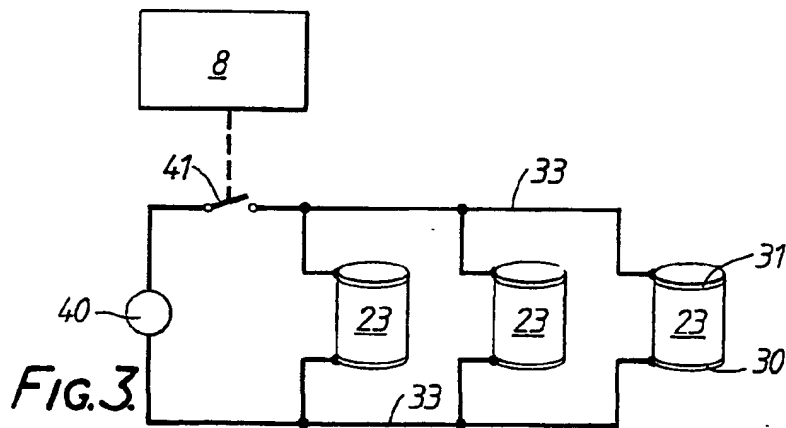


FIG. 3.

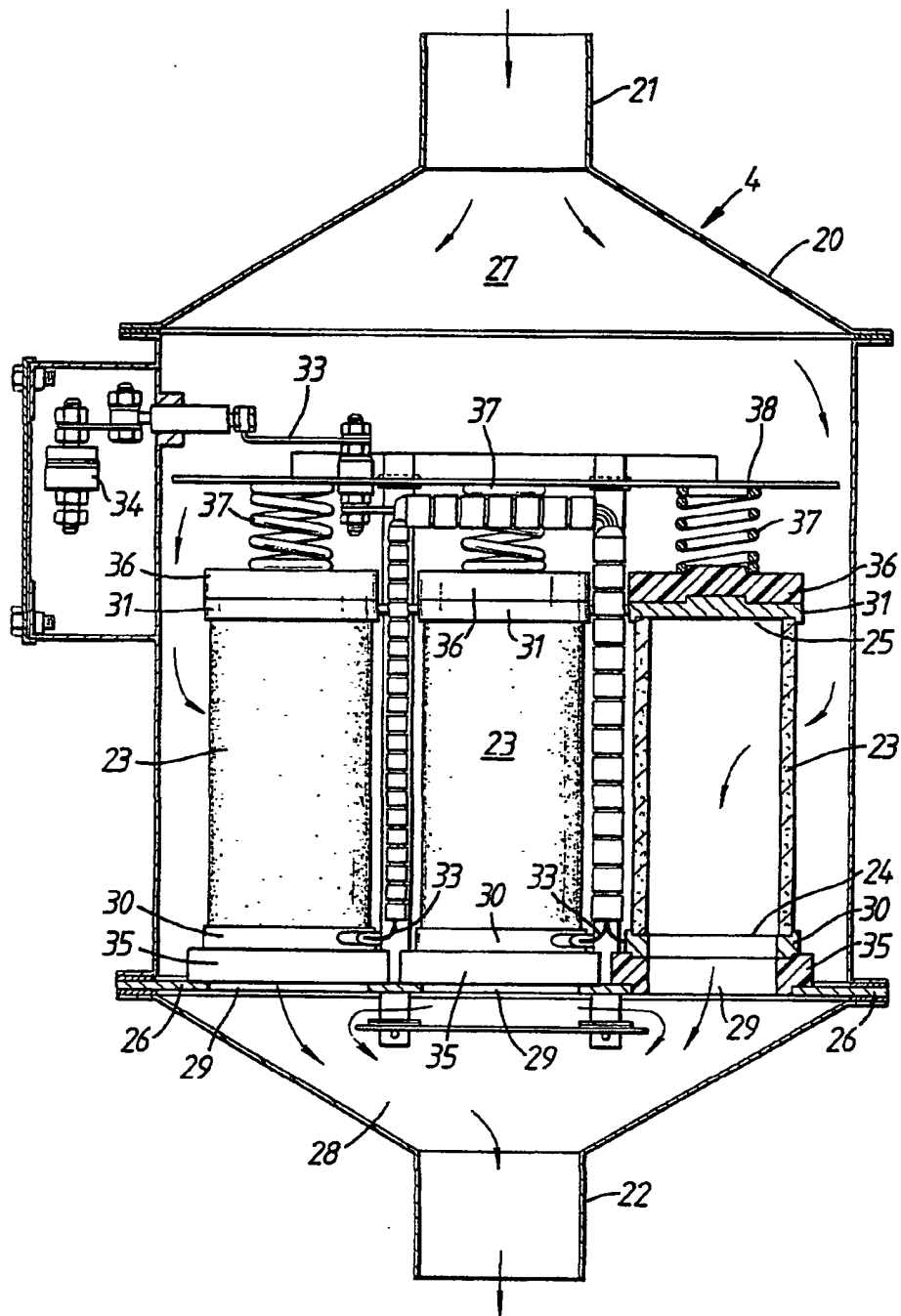


FIG. 2.

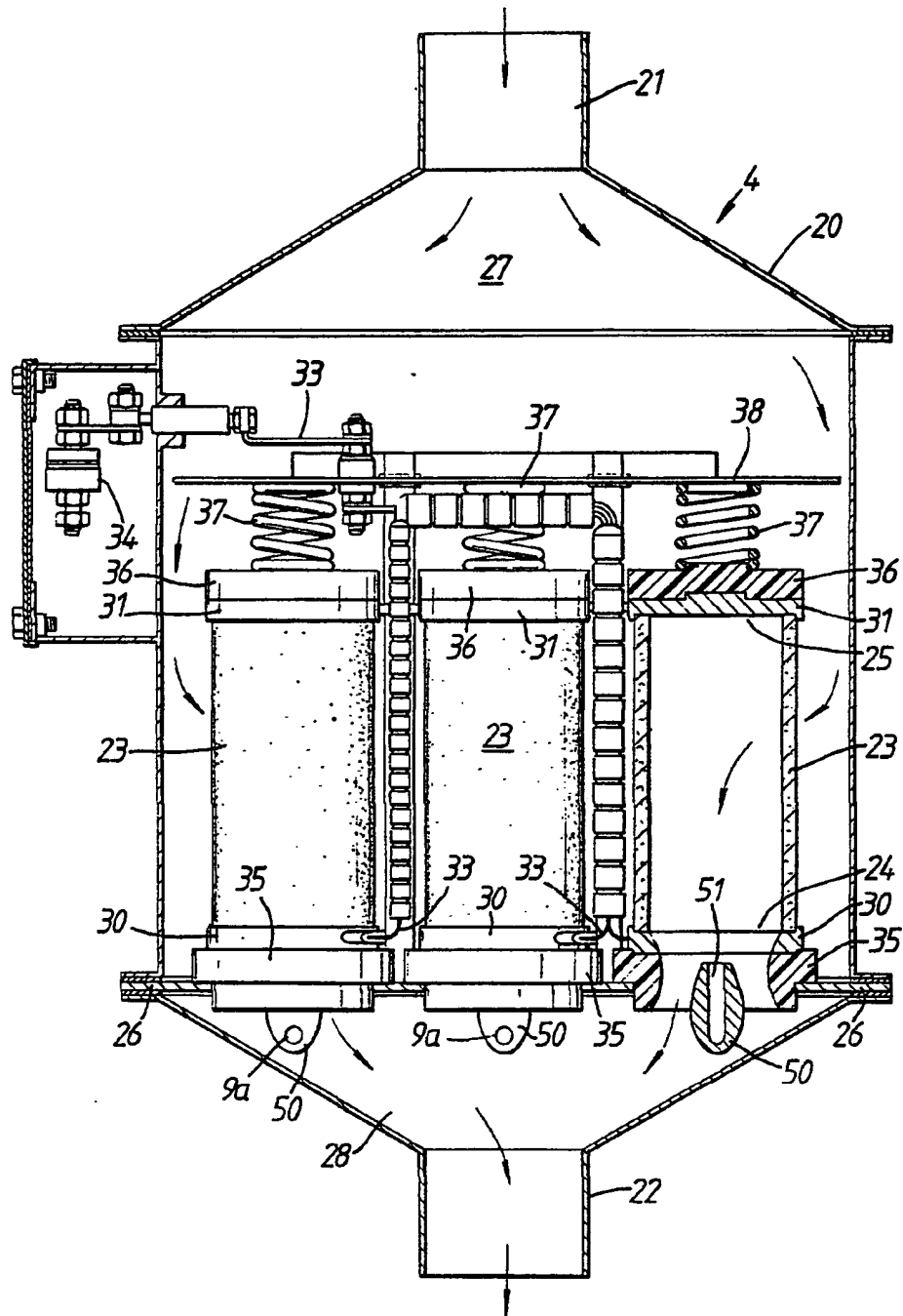
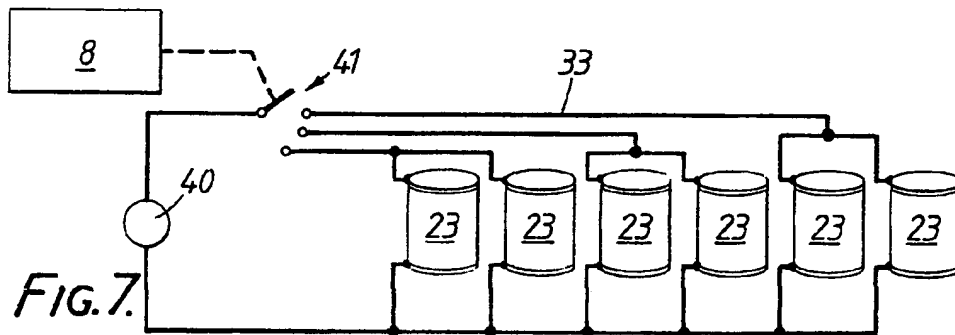
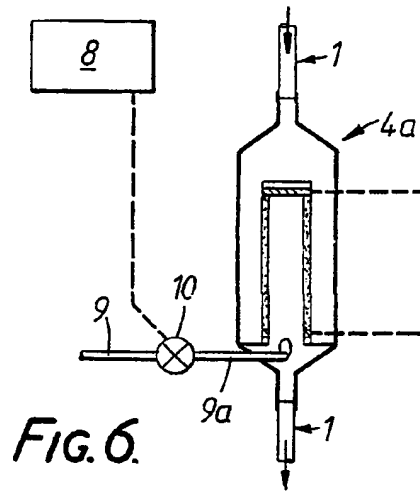
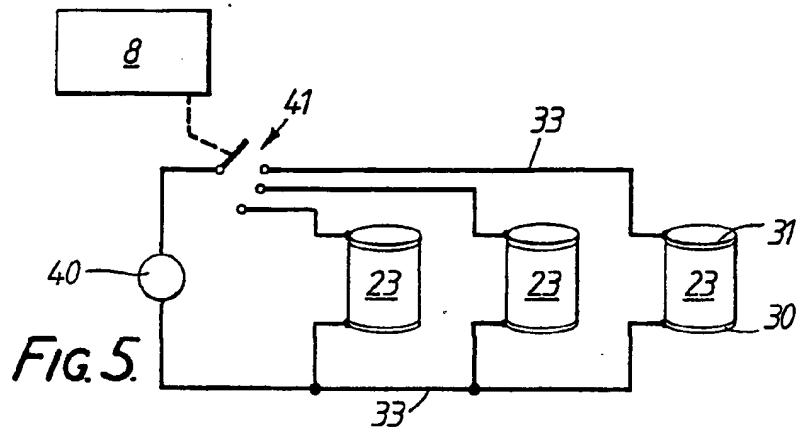


FIG. 4.





EP 87 30 1705

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	US-A-4 558 565 (AKIKAZU KOJIMA) * Column 2, lines 21-44; column 3, line 48 - column 5, line 49; figures 1,2,4,13; claims 1-3 *	1-4,6	F 01 N 3/02 B 01 D 46/24
A	--- US-A-4 281 512 (K.L. MILLS) * Column 3, line 58 - column 5, line 56; figures 1,2 *	1-4,5- 7,24	
A	--- US-A-4 485 621 (V.W. WONG) * Whole document *	1-3,5 20,21 24	
A	--- PATENT ABSTRACTS OF JAPAN, vol. 10, no. 66 (M-461)[2123], 15th March 1986; & JP-A-60 212 610 (HISASHI IMAI) 24-10-1985	8,9,16 ,15,16	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
A	--- PATENT ABSTRACTS OF JAPAN, vol. 8, no. 124 (M-301)[1561], 9th June 1984; & JP-A-59 28 012 (NIPPON JIDOSHA BUHIN SOGO KENKYUSHO K.K.) 14-02-1984 -----	17-19	F 01 N 3/00 B 01 D 46/00
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 07-06-1987	Examiner POLESAK, H.F.
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document</p>			